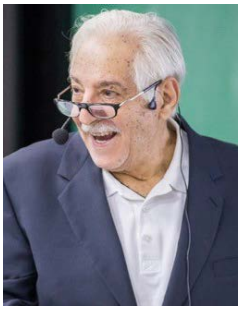
IN RICORDO DI

Rodolfo Bonifacio (1940-2016)



Rodolfo Bonifacio was a pioneer of optical and laser physics who made extraordinary contributions to the subject and helped shape it into its present form. He did this with such passion and energy that nobody who worked with him could forget the experience.

Born in Messina, Sicily in 1940, he moved to Milan where he attended the University of Milan and graduated in physics under the supervision of Piero Caldirola in 1964.

He started his research at a time when quantum and non-linear optics was fast developing, shortly after lasers generated their first coherent light. One of his first papers, with Tito Arecchi, derived the nonlinear equations which describe an electromagnetic pulse interacting self-consistently with an ensemble of two-level atoms. In deriving the Maxwell-Bloch equations (or, more accurately, the Arecchi-Bonifacio equations) they introduced the Slowly Varying Envelope Approximation for the electromagnetic pulse and demonstrated a hyperbolic secant π-pulse solution. This research developed further into the late 1960's while at Harvard, where he was invited by Roy Glauber, and then on Rodolfo's return to Milan in the 1970s.

In 1970 Rodolfo formulated, in collaboration with Paolo Schwendimann and Fritz Haake, a classical and a quantum theory of Cooperative Spontaneous Emission. He coined the name Superfluorescence to designate the emission from a collection of two-level atoms in the excited state, under conditions of vanishing atomic dipole. Later, together with Luigi Lugiato, he provided the theoretical description of oscillatory superfluorescence. His predictions were nicely confirmed experimentally.

In the mid-1970s, in collaboration with Luigi Lugiato, Rodolfo proposed the mean-field theory of Optical Bistability, which was generally adopted by the community, and described the quantum features of the transmitted light and of the photon statistics. They also formulated an exact theory of optical bistability in a ring cavity, which allowed the prediction of the phenomenon of optical self-pulsing, later observed in experiments.

In the late 1970s Rodolfo turned his attention to a new source of coherent radiation, the Free Electron Laser (FEL), which uses a beam of relativistic electrons interacting with a magnetostatic wiggler field as the radiation source, rather than a "conventional" lasing medium involving internal, bound states of atoms or molecules. In 1982 he, with co-authors, Federico Casagrande and Giulio Casati, described a model of a FEL and showed that when the amplitude of the wiggler field or the electron beam density exceeds a critical value, a first-order-like transition to strongly coupled chaotic motion takes place and the system radiates strongly and cooperatively.

This was followed by further studies of the FEL throughout the 1980s and 1990s which described, among many other things, the spatio-temporal properties of Self- Amplified Spontaneous Emission, the radiation emitted when the FEL starts from noise. This was the operating regime of the first X-ray FEL developed at the Stanford Linear Accelerator Center and first operated in 2009.

Rodolfo's experience with conventional "atomic" and free electron lasers led him in the mid-1990s to investigate light-matter interactions in atomic gases by borrowing concepts from both fields. At this time, experimental progress on cooling and trapping atomic gases was advancing rapidly, but little consideration had been given to how the extremely low temperature of a gas would affect its interaction with light. In 1994 Rodolfo led the development of the "Collective Atomic Recoil Laser" (CARL) – a theory of light amplification in a cold atomic gas which relies on both the internal bound atomic states and atomic centre-of-mass motion to produce a collective bunching of the atoms and subsequently coherent scattering of an incident pump field. CARL has since been observed in experiments involving cold, thermal gases but also in Bose-Einstein Condensates (BECs) as a process termed "Superradiant Rayleigh Scattering (SRyS)".

SRyS experiments involving ultra-cold BECs stimulated the extension of the CARL model to include a quantum description of the atomic recoil due to photon scattering. This in turn led Rodolfo to revisit high-gain FEL theory in the early 2000s and investigate the possibility of a high-gain Quantum FEL (QFEL) regime involving a collective bunching instability in which the discrete nature of the electron-light momentum exchange is highly significant. Building on the ground-breaking work by Giuliano Preparata in the late 1980s on this topic, Rodolfo pushed forward the development of the QFEL model as the potential basis of a compact source of coherent gamma-ray radiation and worked actively on it until his death.

In recognition of his important results and scientific achievements, Rodolfo Bonifacio was awarded in 1987 the Michelson Medal from the Franklin Institute for his studies of optical bistability, and in 1994 the Einstein Medal from the Society for Quantum Optics and Quantum Electronics for his pioneering work on FEL.

Rodolfo Bonifacio's scientific legacy is safe in his considerable catalogue of seminal publications. What is not recorded, except by those who knew him, was his passion for physics and love of life. Both can be observed in his last seminar, ironically on the topic of the quantisation of time, something that has been of great interest to him for many years. He often joked that he had become a scientific "heretic" in some circles for proposing such a model. You can judge for yourself by watching it here: `https://www.youtube.com/watch?v=ZzKO7Tfmpmg`

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Ricordi personali

Oltre al valore indiscutibile dei risultati scientifici raggiunti, da Rodolfo, di cui siè già dato conto, vorrei qui sottolineare la grande passione che metteva in tutto ciò che faceva, nella ricerca come nella vita, e lo faccio attraverso alcuni personali ricordi.

Non era mai appagato dei risultati ottenuti ed era costantemente alla ricerca di qualcosa di nuovo, questo anche nella vita. Qualche brevissimo flash illustra la sua personalità meglio di mille parole. Lo ricordo entrare un giorno nel mio ufficio esclamando: "Giulio, non hai idea di come sono felice, ho trovato casa qui vicino, a 100 metri, e mi posso alzare dal letto e dopo 10 minuti essere in ufficio". Dopo non molto tempo entra nel mio ufficio e sempre con grande entusiasmo dice: "Giulio, mi sono trasferito in una casa, lontano, sul lago di Garda. Sono felice, me ne sto in pace in un posto bellissimo e quando voglio in due ore sono in ufficio a Milano". Molte scelte nella sua vita sono state di questo tipo, determinate da entusiasmi improvvisi, e per questo suo carattere non era facile andare d'accordo con lui vivendogli vicino. Io stesso ho avuto con lui momenti di grande intesa e anche momenti di attrito. Poi, una delle sue improvvise decisioni lo ha portato lontano da Milano e l'ho quasi perso di vista, a parte contatti molto sporadici.

Meno di tre mesi prima del suo decesso ricevo da lui questo mail dal Brasile: "che bello Giulio, sono le 4 del mattino ed il tuo mail mi dà un buon giorno… Per il resto, a parte un cancro al fegato in fase terminale, sto bene…". Nel seguito del mail, quasi non ci credevo, mi parla con entusiasmo di un argomento di fisica che al momento lo appassiona, la quantizzazione del tempo, del quale ci eravamo occupati tempo fa. Che dire! A noi piace ricordarlo così con questo suo trasporto e passione per le cose che faceva, che lo ha accompagnato per tutta la vita fino all'ultimo istante. Rodolfo: siamo addolorati perché ci hai lasciato, siamo contenti perché sei stato tra noi.

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